CLAIMS

We claim:

1. A method for producing a nitrogen trifluoride product, the method comprising:

providing a reaction mixture comprising an ammonium ion source and a perfluorcarbon compound wherein at least a portion of the ammonium ion source comprises a solid; and

introducing a fluorine reactant to the reaction mixture for one or more temperatures sufficient to effect a reaction and thereby form the nitrogen trifluoride product.

2. The method of claim 1 further comprising the step of heating the reaction mixture to substantially solubilize at least a portion of the ammonium ion source within the perfluorocarbon fluid.

3. The method of claim 1 further comprising the step of introducing an ammonia gas into the reaction mixture.

4. The method of claim 3 wherein the reaction is performed in a continuous manner with the fluorine reactant and the ammonia gas added to the reaction mixture.

5. The method of claim 1 wherein the temperature ranges from about 60°C to about 144°C.

6. The method of claim 5 wherein the temperature ranges from about 90°C to about 120°C.

7. The method of claim 6 wherein the percentage yield of the nitrogen trifluoride product is about 80% or greater.

8. The method of claim 7 wherein the percentage yield of the nitrogen trifluoride product is about 90% or greater.

9. The method of claim 1 wherein the weight-to-volume ratio of the ammonium ion source to the perfluorocarbon fluid ranges from 4:1 to 1:2.

10. The method of claim 1 wherein the weight percentage of the ammonium ion source to the perfluorocarbon fluid in the reaction mixture ranges from 1% to 99 weight %.

11. The method of claim 1 wherein the ammonium ion source is at least one from the group consisting of NH_3, NH_4F, NH_4HF_2, NH_4Cl, NH_4Br, NH_4I, NH_4NO_3, $(NH_4)_3PO_4$, $(NH_4)_2SO_4$, $(NH_4)_2CO_3$, NH_4HCO_3, NH_4HSO_4, NH_4OSO_2F, NH_4OSO_2Cl, $NH_4OSO_2CF_3$, $NH_4OSO_2CH_3$, $NH_4OC(O)CF_3$, $NH_4OC(O)CH_3$, $NH_4N(SO_2CF_3)_2$, NH_4OIOF_4, NH_4OTeF_5, NH_4NO_3, $(NH_4)_3PO_4$, NH_4IO_4, NH_4ClO_4, NH_4BrO_4, and mixtures thereof.

12. The method of claim 11 wherein the ammonium ion source comprises ammonium fluoride.

13. The method of claim 11 wherein the ammonium ion source comprises ammonium bifluoride.

14. The method of claim 11 wherein the ammonium ion source comprises ammonia.

15. The method of claim 1 wherein the ammonium ion source comprises a compound of the formula $(NH_4)_yMF_z \cdot nHF$ wherein M is one or more elements selected from Group 1 through Group 18 of the Periodic Table of the Elements; y is a number that ranges from 1 to 4; z is a number that ranges from 2 to 8; and n is an amount that is sufficient to maintain the compound as a liquid in the exisiting reaction conditions.

16. The method of claim 1 wherein the ammonium ion source comprises a compound of the formula $(NH_4)_xM_yA \bullet nHF$ wherein M is one or more elements selected from Group 1 through 18 of the Periodic Table of the Elements; A is an anion from the group consisting of carbonate, bicarbonate, phosphate,

sulfate, nitrate, periodate, perbromate, or perchlorate; x is a number that ranges from 1 to 3; y is a number that ranges from 0 to 2; and n is an amount that is sufficient to maintain the compound as a liquid in the reaction mixture.

17. The method of claim 1 wherein the ammonium ion source is a spent reaction mixture.

18. The method of claim 1 wherein the ammonium ion source is at least one selected from the following:

a. NH_3, NH_4F, NH_4HF_2, NH_4Cl, NH_4Br, NH_4I, NH_4NO_3, $(NH_4)_3PO_4$, $(NH_4)_2SO_4$, $(NH_4)_2CO_3$, NH_4HCO_3, NH_4HSO_4, NH_4OSO_2F, NH_4OSO_2Cl, $NH_4OSO_2CF_3$, $NH_4OSO_2CH_3$, $NH_4OC(O)CF_3$, $NH_4OC(O)CH_3$, $NH_4N(SO_2CF_3)_2$, NH_4OIOF_4, NH_4OTeF_5, NH_4NO_3, $(NH_4)_3PO_4$, NH_4IO_4, NH_4ClO_4, NH_4BrO_4'

b. a compound of the formula $(NH_4)_yMF_z \cdot nHF$ wherein M is one or more elements selected from Group 1 through Group 18 of the Periodic Table of the Elements; y is a number that ranges from 1 to 4; z is a number that ranges from 2 to 8; and n is an amount that is sufficient to maintain the compound as a liquid in the exisiting reaction conditions; or

c. a compound of the formula $(NH_4)_xM_yA \cdot nHF$ wherein M is one or more elements selected from Group 1 through 18 of the Periodic Table of the Elements; A is an anion from the group consisting of carbonate, bicarbonate, phosphate, sulfate, nitrate, periodate, perbromate, or perchlorate; x is a number that ranges from 1 to 3; y is a number that ranges from 0 to 2; and n is an amount that is sufficient to maintain the compound as a liquid in the reaction mixture; and mixtures thereof.

19. The method of claim 1 wherein the reaction mixture is agitated.

20. The method of claim 1 wherein the fluorine reactant is introduced at a rate of 40 lbs per hour or greater.

21. A method for producing a nitrogen trifluoride product, the method comprising:

combining an ammonium ion source and a perfluorocarbon fluid to form a reaction mixture wherein at least a portion of the ammonium ion source comprises a solid;

heating the reaction mixture to substantially solubilize at least a portion of the ammonium ion source within the perfluorocarbon compound; and

introducing a fluorine reactant to the reaction mixture for one or more temperatures sufficient to effect a reaction and thereby form the nitrogen trifluoride product.

22. The method of claim 21 further comprising the step of introducing an ammonia gas into the reaction mixture.

23. The method of claim 21 wherein the temperature ranges from about 60°C to about 144°C.

24. The method of claim 23 wherein the temperature ranges from about 90°C to about 120°C.

25. The method of claim 24 wherein the percentage yield of the nitrogen trifluoride product is about 80% or greater.

26. The method of claim 25 wherein the percentage yield of the nitrogen trifluoride product is about 90% or greater.

27. A method for producing a nitrogen trifluoride product at a high yield, the method comprising:

combining an ammonium ion source and a perfluorocarbon fluid to form a reaction mixture wherein the ammonium ion source comprises a solid;

heating the reaction mixture to substantially solubilize at least a portion of the ammonium ion source within the perfluorocarbon fluid; and

introducing a fluorine reactant to the reaction mixture for one or more temperatures ranging from about 90°C to about 120°C to effect a reaction and thereby form the nitrogen trifluoride product wherein the percentage yield of the nitrogen trifluoride product is about 80% or greater.

28. The method of claim 27 further comprising the step of introducing an ammonia gas into the reaction mixture.

29. The method of claim 28 wherein the reaction is performed in a continuous manner with the fluorine reactant and an ammonia gas added to the reaction mixture.

30. The method of claim 27 wherein the reaction mixture is agitated.

31. The method of claim 27 wherein the fluorine reactant is introduced at a rate of 40 lbs per hour or greater.